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Environmental Effects of Dredging Technical Notes

Implementation Approach for Thalweg Disposal of Dredged Material

Purpose

This technical note introduces the concept of thalweg disposal and associated considerations for implementation, including disposal site selection, environmental and regulatory considerations, and suitable dredging methods and equipment. Monitoring procedures are also outlined.

Background

The thalweg of a river is defined by a line whose course is given by connecting the lowest points along the streambed for each transect. The thalweg's course passes through pools at river bends and through crossings between the bends. During high-discharge events along a river system, pool areas scour and crossings accrete material. The opposite takes place during low-discharge periods, but with a lower magnitude of change. Blockages to navigation generally occur at the crossings.

The concept of thalweg disposal is to dredge the shallow reaches and dispose the dredged material in a downstream pool. Thalweg disposal is a form of open-water disposal and is regulated under Section 404 of the Clean Water Act (CWA). The "Guidelines for Specification of Disposal Sites for Dredged or Fill Material," outlined in 40 CFR 230, apply (U.S. Environmental Protection Agency (EPA) 1980).

Additional Information

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Concept of Thalweg Disposal

Thalweg disposal refers to the practice of disposing of dredged material by discharge into the naturally occurring scour holes within a river—a form of open-water disposal specific to these locations. A more rigorous description has been given by the U.S. Army Engineer District (USAED), Rock Island, as follows: "Thalweg disposal is placement of dredged material in a deep-water portion of the channel thalweg where it will become a natural element of the sediment transport system, and will be assimilated into the system with minimal impacts to either the sediment transport system or the environment" (Nanda and Baker 1984). In practice, thalweg disposal mimics a cut-and-fill operation, whereby a shallow crossing is dredged and the material is moved into a downstream pool. Thalweg disposal is therefore similar to the natural process of low-water scour and accretion of crossings and pools, although greater in rate and magnitude. Theoretically, if the volume to be dredged is small compared with the total annual transport, the energy increment used to move the sediment from crossing to pool should have little overall effect on the regime of the river (Lagasse 1975).

By definition, the thalweg of a river follows the line connecting the lowest points along a streambed. The thalweg will meander back and forth across the riverbed in response to the changing course of the river, as shown in Figures 1 and 2. At many locations within the thalweg, the depth is sufficient to permit dredged material disposal without interference to navigation. Figure 3 illustrates this concept, before and after disposal.

Thalweg disposal has been proposed as a disposal alternative for uncontaminated sediments and as an alternative to the use of sidecasting dredges, which have the disadvantage of high disturbance and a tendency for redeposition of material in the cut. Thalweg disposal offers potential economic advantages, eliminating the need to transport dredged material to confined disposal sites, and the costs associated with acquisition, development, and maintenance of those sites.

The USAED, Rock Island, has reported costs of approximately $1.80 to 2.00 per cubic yard for thalweg disposal. Unit costs are influenced by the amount of material to be dredged and the distance to the disposal site. Typically, 4,000 to 5,000 ft of pipeline is required for a hydraulic dredging and disposal operation. Monitoring requirements of the disposal process and long distances can in some cases increase the cost of thalweg disposal over that of other riverine disposal methods (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

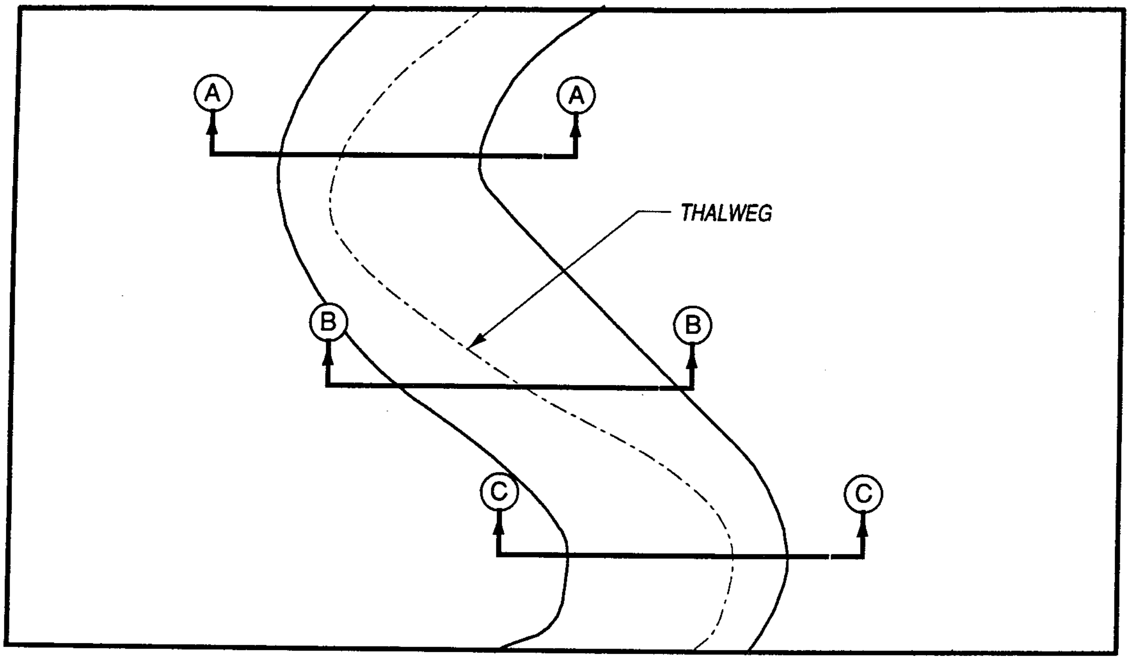

Figure 1. Line of the thalweg

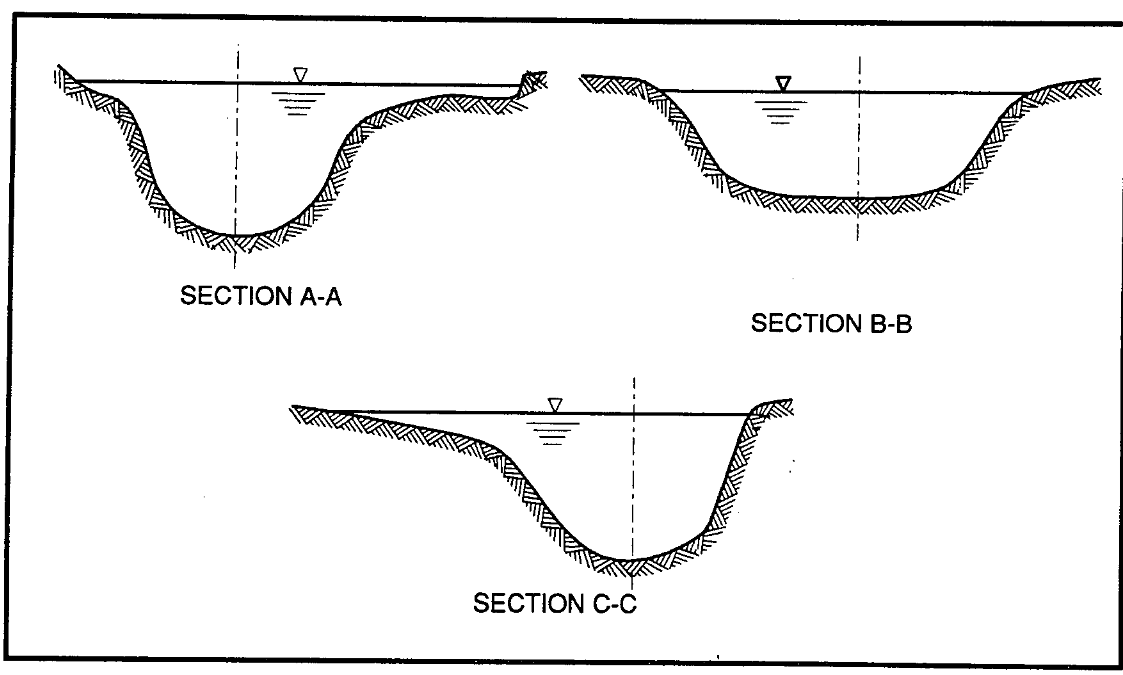

Figure 2. Section depicting location of the thalweg

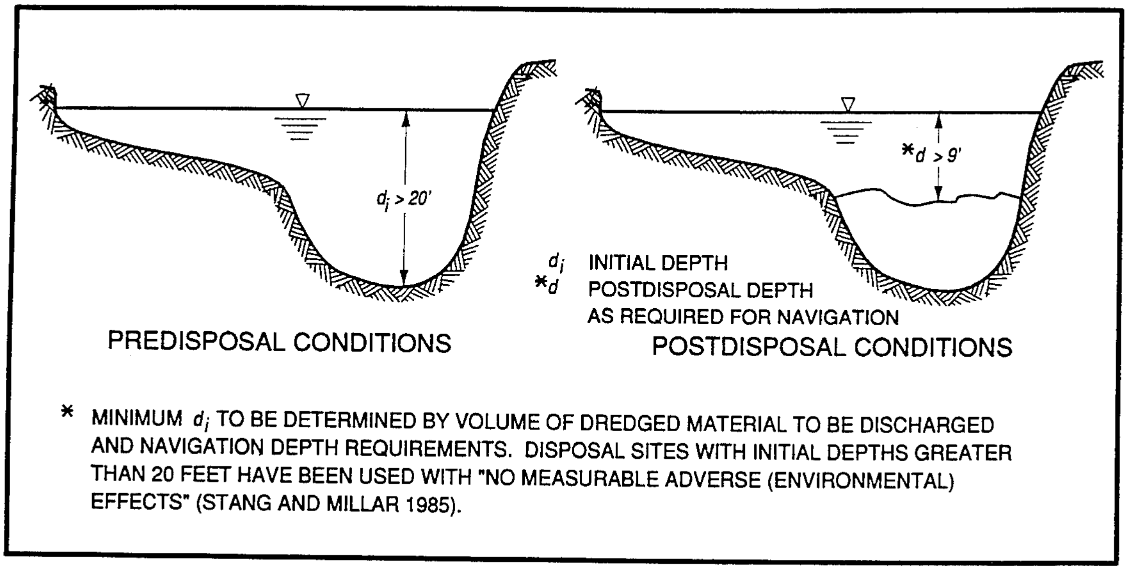

Figure 3. Section view of disposal site

Implementation

Application

Thalweg disposal has the potential to be an economic form of dredged material disposal which, when appropriately implemented, will have a minimal impact on the environment. River reaches requiring relatively low-volume dredging are the best candidates for thalweg disposal, while river reaches with divided flow are marginal candidates (although such reaches are most commonly dredged). Reaches that require heavy dredging should not be considered for thalweg disposal (Simons and Chen 1980). Thalweg disposal is most applicable to clean, sandy sediments, although in some cases it may be used for contaminated sediments as well, depending upon the nature and degree of contamination and the relative locations of extraction and disposal sites (EPA 1980).

Decision Structure

Implementation of thalweg disposal involves the reconciliation of various factors, including regulatory requirements, habitat preservation, and technical feasibility. Figure 4 illustrates the interdependence of these factors. The chronology of the decision structure will depend on what information is most readily available initially, coupled with those criteria that are most likely to be the limiting factors in the decision-making process. For example, the availability of potentially less damaging, or existing, disposal alternatives may negate further investment in evaluation of thalweg disposal. The availability of suitable disposal sites in reasonable proximity to dredging sites or the presence of contaminated sediments may possibly be determined from existing information, thus determining the next appropriate areas of inquiry and minimizing the evaluation process.

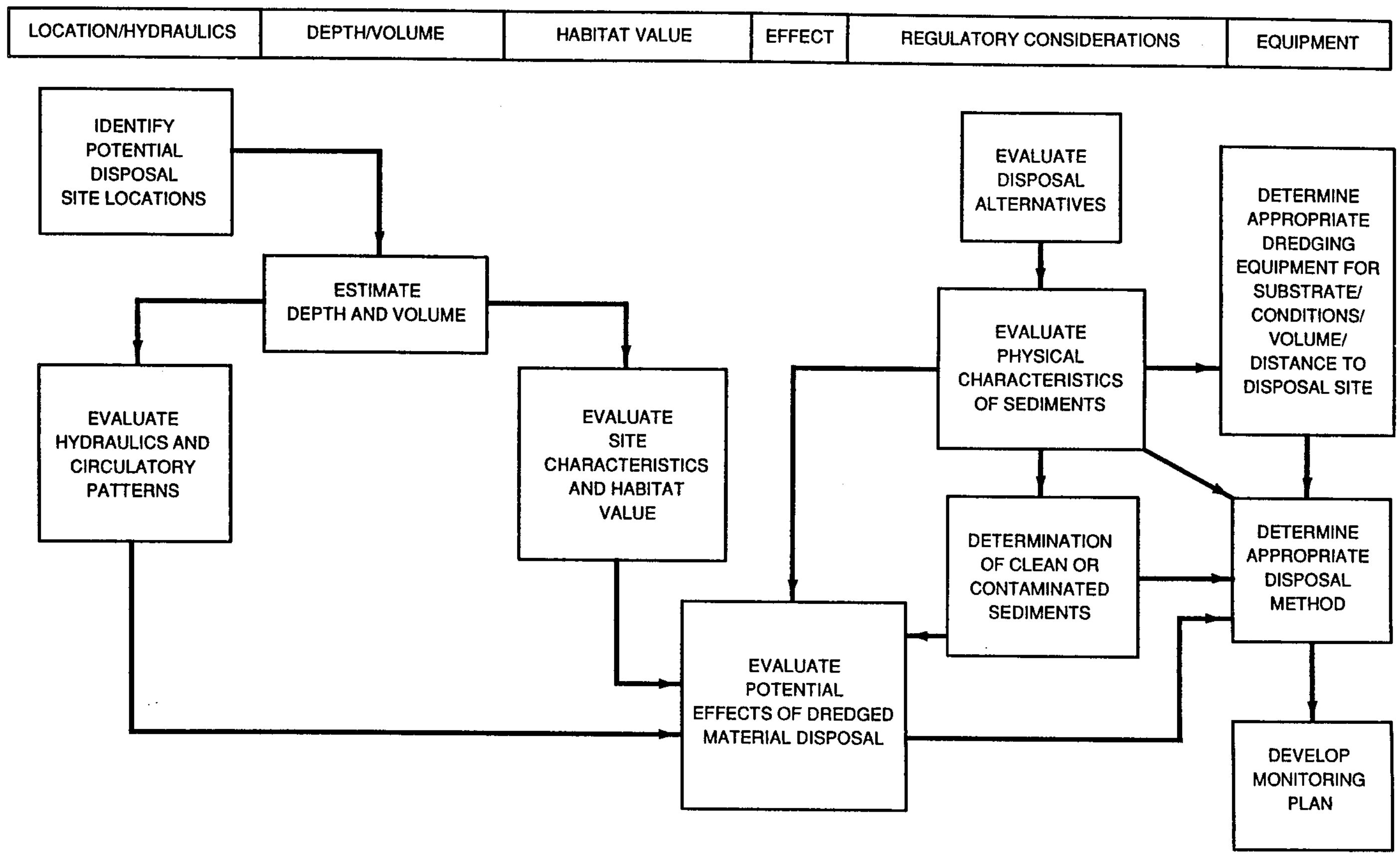

Figure 4. Interaction among operational/environmental and regulatory parameters in thalweg disposal

A feasibility study could begin with identifying locations where dredging is anticipated, or where it has historically been necessary, as well as potential thalweg disposal sites downstream of these areas which, from existing bathymetric information, would appear to be of suitable depth. Disposal alternatives for these locations could then be evaluated. If thalweg disposal appears to be a viable and justifiable alternative, further study would be initiated, according to the areas of importance outlined in Figure 4. Determinations can thus be made regarding the availability of suitable disposal sites, the technical and economic feasibility of the process, and environmental and regulatory acceptability. In general terms, the approach would be:

- **Collect available information**

  —Bathymetric surveys

  —Dredging logs

  —Sediment characterization (grain size, sediment chemistry, etc.)

- **Make preliminary determinations based on this information**

  —Proximity of potential thalweg disposal sites to dredging sites

  —Other disposal alternatives

  —Potential limitations to the process

    - Contaminated sediments
    - Obvious adverse site characteristics
    - Other considerations as indicated in Figure 4 and for which information is in hand

- **Proceed with further evaluation of most viable alternatives**

  —Addressing all areas of Figure 4:

    - Collect further information as required to proceed with evaluation
    - Identify concerns
    - Select most feasible and environmentally appropriate alternatives
    - Develop site-specific implementation plans
      - Boundaries of disposal site
      - Disposal volume
      - Seasonal disposal "window"
      - Monitoring and testing as required
      - Other pertinent considerations

Site Selection

Potential disposal sites should be identified well in advance of need so that site characteristics can be investigated. Environmental assessments and 404 evaluations may require as much as 2 years lead time prior to implementation of a site (personal communication, January 1993, Richard M. Baker, USAED, Rock Island). Preliminary identification can be made using dredging records and documented river geomorphology (Simons and Chen 1980). Sites that show evidence of high habitat value or potential for adverse effects due to undesirable alteration of current patterns and sediment movement are to be avoided.

As previously suggested, site selection will appropriately begin with identification of areas where disposal sites may be available within practical range of dredging sites (Simons and Chen 1980) and a review of available information to determine where the thalweg is of sufficient depth and volume to merit further consideration. Necessary depth will be determined from navigation requirements and the anticipated volume of dredged material to be discharged.

Detailed bathymetry of the disposal site and the reach 1 to 2 miles downstream must be obtained, provided the site is not first eliminated on the basis of other criteria (Figure 4). Potential disposal sites should then be evaluated on the basis of hydraulic characteristics. Millar (1986) recommends that the general morphology and hydraulics of the area for high- and low-flow periods be documented, and that bathymetric measurements be made of the disposal area and the thalweg/main channel for approximately 0.75 mile downstream.

The USAED, Rock Island, compiles detailed bathymetry of both the dredging and disposal sites, as well as nearby side channels and back waters in a 1- to 2-mile reach (personal communication, January 1993, Richard M. Baker, USAED, Rock Island). This distance will be site-specific, and typically will be determined in response to the concerns of local permitting agencies with respect to a particular river reach.

Depth

Stang and Millar (1985) recommend the use of sites that are at least 20 ft deep. Deeper holes will have correspondingly higher potential as disposal sites. Relative depth of the thalweg and side channel inlets is also of importance. The depth of the thalweg should exceed the depth of side channel inlets by at least 10 to 20 ft within potentially affected reaches (1 to 2 miles downstream of a disposal site) (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

Fate of Sediments

Thalweg disposal can potentially have an effect on circulation patterns and water-level fluctuations, as well as contributing sediment to reaches and

structures immediately downstream of the disposal site. Lubinski (1984) suggested that, after placement in the thalweg, dredged material either remained at the site or was assimilated into the bed load, where it could then migrate in response to water currents.

Thalweg disposal has been used to some extent on the lower Mississippi River, and the Rock Island District has used and studied the procedure on the upper Mississippi River. Lower Mississippi dustpan dredging operations use the procedure when the river stage is such that access to holes downstream from the extraction site is possible. While there may be some movement of sediment out of the disposal site, in this area it constitutes a small fraction of the bed load, and effects are considered to be negligible (personal communication, August 1992, Mr. Larry Rabalais, USAE Division, Lower Mississippi Valley).

Studies of the movement of sand, tagged with fluorescent dye, from four test sites on the upper Mississippi River (Savannah Bay, Whitney Island, Gordons' Ferry, and Duck Creek) were conducted by the Argonne National Laboratory. Results of a 9-month observation of the Savannah Bay site (Paddock and McCown 1984) correlated closely with results obtained at the Whitney Island and Gordons' Ferry sites. This investigation revealed that contours of the disposal mound had been altered and dunes had developed, similar to the original bottom configuration of the river. Movement of tagged sand from the original site was observed, apparently confined to within the thalweg, and occurred in response to high river discharge.

At the Gordon's Ferry site, sampling that was conducted after a 5-year flood event (at a time approximately 20 months after disposal) revealed downstream movement of tagged sand for a distance of approximately 1,000 m.

Tagged material redistributed outside the thalweg was thought to be primarily fines and not representative of the characteristics of typical dredged material. It was concluded that "virtually no movement of dredged material into side channels occurs where the thalweg is at least 10 to 20 feet deeper than the channel inlet. Where the side channel inlet and the thalweg are of similar depth, however, migration of material into the side channel can be assumed. Side channel accretion may be due to sand input from the channel border area" (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

In the sites tested and sampled, the disposal mounds were eradicated by the first flood. Tagged sand appeared to have been incorporated into the bed forms of the natural channel (Ditmars, McCown, and Paddock 1986). A similar experiment conducted in a more complex reach with submerged wing dams on either bank resulted in a return to original depth within 5 months (September to January) after disposal (Ditmars, McCown, and Paddock 1986). Further monitoring of other, more diverse sites will be necessary to determine whether the behavior of these sites is representative.

As part of investigations conducted at Waterways Experiment Station for the St. Louis District, two tests in a physical movable-bed model were conducted for the Dogtooth Bend reach of the middle Mississippi River (miles 39.6 to 20.2). Considerable channel stabilization work was been done at this location, including weirs, dikes, and revetments, all designed to increase channel depth and improve navigation. The model used granulated coal as both dredged material and bed medium. Plastic particles were mixed with the dredged material to act as tracers. One test examined disposal along the opposite bank from the dredge cut and in scour holes off the ends of dikes. True thalweg disposal was not examined. Sediment transport, rate of movement, and areas of deposition were examined and recorded. Preliminary results were encouraging in that, for the limited testing performed, material deposited in the scour holes at the stream end of dikes did not negatively impact the navigation channel in the two bends and crossing downstream of the disposal site. However, a more intensive study would be needed to determine if results were representative of the behavior of sediments in natural channels.

Hydraulics

The following are some general guidelines to site selection on the basis of hydraulics:

- Where a disposal site is located upstream of an island, adverse effects may result if the thalweg current is of equal force on both sides of the island, or if there is more force down the side channel than in the main channel (Millar 1986).
- Thalweg disposal should not be used where the depositional pool or downstream crossing is not of adequate depth to handle the material without further dredging (Millar 1986).
- No thalweg disposal site should be located within 2 miles upstream of a high-volume dredging site (Simons and Chen 1980). [The Rock Island District has used thalweg disposal within 1 mile of a high-volume dredging site with no adverse impacts on the site. Increased scour was noted on the next crossing. The cause-and-effect relationship in this instance was not determined, but the site has been used three times with similar results (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).]
- When the disposal site is located adjacent to or immediately upstream from the entities listed below, the potential for adverse effects due to sediment movement from the disposal site, during and after disposal, exists. These entities include

  —Tributaries.

  —Hydraulic/navigational structures.

  —Water supply intakes.

  —Important habitat.

—Submerged artifacts.

—Recreational or commercial fisheries.

—Other sensitive areas, by site-specific determination. [The Rock Island District has not experienced any problems due to thalweg disposal near navigational structures (training works) (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).]

- No side channels and backwater areas should be located within 1 mile downstream of the disposal site (Simons and Chen 1980). [Side channel entrance depth relative to thalweg depth appears to be the most critical factor. Where the thalweg is at least 10 to 20 ft deeper than the side channel inlet, movement of dredged materials into the inlet is not expected to occur. Where they are of similar depth, material migrating from the disposal sites may accrete in the side channel inlet (personal communication, January 1993, Richard M. Baker, USAED, Rock Island). This would not be reflected in a one-dimensional analysis that assumes equal transport through the cross section.]

The hydraulics of such locations must be carefully evaluated if they are to receive further consideration. Postdisposal monitoring, with an action plan for intervention, may be advisable. An intervention trigger might be a specified change in bathymetry, or increased turbidity above background levels (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

Environmental Effects

The habitat value of potential disposal sites must also be evaluated. In general, sites with the following characteristics should not be considered for thalweg disposal:

- Significant numbers of aquatic or benthic organisms.
- Presence of endangered species.
- High species diversity.
- Dormant species at time of disposal.
- Bottom-dwelling species.

Avoidance of sites with these characteristics is a primary objective in evaluation of potential disposal sites. A careful evaluation of depth, substrate, and water temperature will be the primary indicators of habitat potential of a site. Because the thalweg is a highly dynamic environment, its physical, chemical, and biological attributes may change on a seasonal basis or in response to changes in water level. In specifying a disposal site, these fluctuations should be taken into consideration. Thalweg disposal should be seasonally restricted as appropriate for local conditions and habitat use. Disposal should be restricted to materials with characteristics (grain size, level of compaction, etc.)

similar to the disposal site (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

In general, coarse stable substrates and structures that provide a current break have demonstrated habitat value. Areas with low velocities or where natural back eddies exist are also good habitat. Sites with high velocities and unstable substrates are generally least valuable as habitat. These conditions are often found on outside bends, which may appropriately be given first consideration in initial site evaluation.

Environmental Effects of Dredging Technical Notes EEDP-01-30, "Environmental Effects Evaluation for Thalweg Disposal of Dredged Material" (Olin 1993), gives detailed information on evaluating potential thalweg disposal sites for various environmental concerns.

Regulatory Considerations

Thalweg disposal is a form of open-water disposal and, as such, is regulated under Section 404 of the CWA. The "Guidelines for Specification of Disposal Sites for Dredged or Fill Material," as outlined in 40 CFR 230, apply to disposal site determination (EPA 1980). Under Section 404 of the CWA, specification of disposal sites and evaluation of dredged material for open-water disposal are addressed. Once a disposal site is specified, a contaminant evaluation of the material must be done. In general, material proposed for thalweg disposal will meet the exclusionary criteria outlined in 40 CFR 230.60, and the testing described in 40 CFR 230.61 need not be performed. The 404(b)(1) evaluation must include State water quality certification as described in Section 401 of the CWA.

Dredging Methods and Equipment

As with any dredging operation, selection of suitable equipment for the sediments, depth, traffic, and adjacent structures is the major consideration. In some cases, it may be necessary or desirable to minimize sediment resuspension during dredging and disposal, which places further requirements on equipment selection. Section 33 CFR 323.2(d) addresses the status of "de minimis incidental soil movement" resulting from "normal dredging operations."

In general, hydraulic dredging is suited to the extraction of loosely compacted materials and results in a slurry with a high water content. Thus, hydraulic dredging can minimize disturbance at the extraction site, but generally contributes to wider dispersion at the disposal site (Palermo and others 1992). Mechanical dredging is appropriate to a wider range of substrates, and materials removed by mechanical dredging remain at or near their in situ density. This minimizes turbidity at disposal.

Constraints on disposal options will be dictated by type of dredging equipment selected, the suspended solids requirements, and distance to disposal site. If dustpan dredges are used, the maximum pipeline length is approximately

800 ft, which limits thalweg disposal to this distance (personal communication, August 1992, Larry Rabalais, USAE Division, Lower Mississippi Valley). Pipeline cutterhead dredges can pump through 5,000 ft of pipeline without additional booster pumps (personal communication, September 1992, Dr. Michael Palermo, U.S. Army Engineer Waterways Experiment Station).

Materials suspended during disposal are regulated under Section 401 of the CWA. Open-ended pipeline disposal, above and parallel to the water surface, maximizes dispersion and produces a thin, widely spread sediment layer. Turbidity can be minimized by using submerged discharge or submerged discharge with diffusers for hydraulically dredged sediments. Where depths exceed 6 ft, dispersion can be decreased by vertically discharging the slurry through a 90-deg elbow at 1.5 to 3 ft below the water surface (Simons and Chen 1980). A vertically oriented, 15-deg axial diffuser with a cross-sectional area ratio of 4 to 1, followed by a combined turning and radial diffuser section that increases the overall area ratio to 16 to 1, can reportedly eliminate most turbidity (Simons and Chen 1980, citing Barnard 1978). Mechanically dredged sediment discharged from barges also results in lower suspended solids levels at disposal.

Hydraulic disposal of materials in discrete mounds to simulate the structure of large dunes has been implemented by the Rock Island District. The environmental advantages of this disposal method relative to disposal in one large mound are not yet known.

In general, the disposal method that is selected must allow for accurate placement of the material in the disposal site, must be technically and physically feasible, and must enable the discharge to conform to the requirements of Section 401 of the CWA.

Monitoring

The thalweg is a dynamic environment, and seasonal changes in physical, chemical, and biological attributes may occur. These changes should be taken into consideration when specifying a site for disposal; however, if a site cannot be located to avoid potential unacceptable adverse environmental effects, postdisposal monitoring may be necessary. If so, the guidance by Fredette and others (1990) should be followed. In particular, "a prospective monitoring program requires that changes in resources at risk be quantified and that the threshold at which changes become unacceptable be explicitly specified."

Although not "monitoring" in the regulatory sense, periodic checks of the area below the dredging site are recommended during dredging and disposal to identify problems that may develop during operations. This may consist of sounding the area with a bathometer every 2 to 3 days during operations to identify areas of excessive accretion or drift of dredged material back into the cut (personal communication, September 1992, Mr. Larry Rabalais, USAE Division, Lower Mississippi Valley). The Rock Island District recommends more frequent monitoring, as much as once every hour, until the rate and pattern of deposition for a particular site have been established. Postdisposal monitoring

is also practiced to obtain data needed for documentation and justification of thalweg disposal (personal communication, January 1993, Richard M. Baker, USAED, Rock Island).

Summary

"Thalweg disposal is placement of dredged material in a deep-water portion of the channel thalweg where it will become a natural element of the sediment transport system" (Nanda and Baker 1984). It mimics the natural low-water scour and accretion of crossings and pools.

Thalweg disposal is an economically viable disposal alternative for appropriately located reaches that require low-volume dredging. Most suitable for clean sediments, the process may be used for disposal of contaminated sediments under certain circumstances. The process of implementing thalweg disposal requires an evaluation procedure by which the important considerations can be reconciled. Figure 4 illustrates the interdependency of the variables involved.

In most cases, potential disposal sites can be identified on the basis of dredging logs and existing bathymetric information. More extensive evaluation can then be restricted to the most promising sites. Location, depth, hydraulic characteristics, and habitat value must all be evaluated, in conjunction with regulatory requirements and feasible dredging techniques.

Thalweg disposal can be reconciled with regulatory requirements for dredged material discharges. As a form of open-water disposal, thalweg disposal is regulated under Section 404 of the CWA. The 404(b)(1) evaluation must include State water quality certification, based on Section 401 of the CWA.

Dredging equipment will be selected in much the same manner as for any dredging operation, with consideration given to sediment characteristics, depth, traffic, adjacent structures, and the presence of contaminants. Where existing turbidity is low, contaminants are present, or where required by regulation, dredging and disposal methods that minimize dispersion and levels of suspended solids may be necessary.

When a disposal site cannot be located to avoid potential unacceptable adverse environmental effects, postdisposal monitoring may be needed. If so, the guidance in Fredette and others (1990) should be followed. Bathymetric monitoring is advisable during and following disposal for accurate material placement and documentation of subsequent effects.

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